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WHAT RESEARCH SAYS ABOUT PROGRAMMING INSTRUCTION.
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"PROGRAMING" IN THIS DISCUSSION REFERS TO THE PROCESS OF PLANNING AND ORGANIZING LEARNING ACTIVITIES, REGARDLESS OF THE MEDIUM TO BE USED. RESEARCH IN PROGRAMING INSTRUCTION SUGGESTS THAT TEACHERS SHOULD (1) AVOID OVERLOADING HIGH ABILITY STUDENTS, (2) AVOID UNDERLOADING AVERAGE AND LOW ABILITY STUDENTS, (3) PLAN THEIR TEACHING AROUND THE EXPECTED STUDENT RESPONSE, (4) EXPECT LEARNER RESPONSES APPROPRIATE TO THEIR BACKGROUND, (5) DEVELOP SKILLS FIRST, TO BE FOLLOWED BY THEIR USE IN MEANINGFUL SITUATIONS, (6) INVOLVE LEARNERS IN MEANINGFUL ACTIVITIES APPROPRIATE TO THE LEARNING TASK, (7) CONSIDER INTELLIGENCE AS ONLY ONE OF A COMPLEX OF FACTORS INFLUENCING THE LEVEL AND PACE OF LEARNING, (8) AVOID TAKING IT FOR GRANTED THAT WHAT IS OBVIOUS TO THE TEACHER IS OBVIOUS TO THE LEARNER, (9) STRIVE TO KEEP INSTRUCTION ORDERLY, COHERENT, ARTICULATED, AND MEANINGFUL, AND (10) CONSTANTLY EVALUATE THE TWO-WAY COMMUNICATION BETWEEN TEACHER AND LEARNER. (AUTHOR/WO)

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What Research Says About Programming Instruction

Programming Instruction is a term which is generally used in connection with machine teaching. The research reported upon in this paper was specifically aimed at solving some of the problems of machine teaching, but the findings apply to all teaching. Programming, in the broad sense, is what all teachers do when they plan their teaching activities; therefore, the problems of machine programming and "teacher programming" are very similar, and the answers to the problems may apply to both situations. Some of the problems, and what we know about the answers, are presented here in the hope that teachers will be encouraged in those activities which are consistent with these findings, and will be guided to reconsider any of their practices which are not consistent with these facts.

PROBLEM ONE

What is the relationship between intelligence of the learner and the rate at which he learns?

ANSWER

There seems to be no general relationship. While ability tests (IQ, SCAT, etc.) indicate the initial performance level, they do not predict speed of learning at that level. A high IQ indicates that an individual has progressed in learning beyond his age peers, but we have no way of knowing how this occurred. A person can learn slowly and have a high IQ if he spends a greater proportion of his time in a better learning environment than does the average person.

PROBLEM TWO

Does higher intelligence mean that a pupil can move more quickly through the curriculum?

ANSWER

The best answer is no. In general, there seems to be no direct relationship between high intelligence and speed of learning. When other factors are at an optimum, certain specific skills or learning tasks are easy for high intelligence, and progress may be rapid; but when other factors interfere (as frequently happens), high intelligence may even handicap the individual. In other words, the amount of material in a curriculum cannot be adjusted up or down to fit the ability level of a class.

PROBLEM THREE

How much new material should be presented at one time?

ANSWER

This depends on two factors, memory span and kind of response expected. As mental age increases, memory span increases, so that older pupils can learn in larger steps. Recognition response is easier than recall response. In recognition response we ask only that the learner be able to identify new material when next it is encountered; in recall response we expect the learner to construct an answer to a question, rather than simply to identify the right answer.

PROBLEM FOUR

When can we expect pupils to be able to solve problems?

ANSWER

As mental age increases, problem solving ability increases, but this increase is probably due to the acquiring of basic skills appropriate to the task. We can expect problem solving ability to appear only after appropriate skills have been developed. Therefore, we cannot expect to teach new skills while solving new problems. We use old skills to solve new problems.

PROBLEM FIVE

Will increased motivation increase learning?

ANSWER

Motivation is essential to learning, but motivation must be appropriate to the learning task. High motivation may interfere with learning when the task is complex and difficult. This is probably due to an increase in emotional involvement; and when emotions reign, reason suffers. In general, motivation should be designed to involve the pupil in meaningful activity appropriate to the learning task. Any motivational activities of the teacher which involve criticism should be criticism of activity rather than criticism of person.

PROBLEM SIX

How complete and detailed should a program be?

ANSWER

School subjects consist of many more "facts" or items of information then generally realized. Machine programmers commonly identify 20 times as many items as teachers thought were contained in a course. Teachers may "skip over" many of these items without realizing the need to cover them at all. Teachers may have an advantage here, in that a machine program must contain all items and (usually) present all items, while the teacher can be flexible in presentation.

PROBLEM SEVEN

What makes a fact meaningful?

ANSWER

In learning a fact, we arrive "at the fact" by reason of some connection (or association) with previously learned facts. A fact is meaningful in the learning sense, if it has at least two connections with other facts; one connection by which we arrive at the fact, plus one connection by which we may move to the "next fact". Additional associations with other facts makes a given fact more meaningful. Some of the facts which we attempt to teach have no natural associative connections with other facts, which leads some teachers to manufacture artificial connections (such as the many devices for remembering the number of days in the months of a year).

In programming, we attempt to arrange facts in meaningful sequence, so that the learner can move through the sequence and thus make learning progress. At the same time, we must establish as many connections as possible so as to fix the learned facts in their relationship to the real world.

PROBLEM EIGHT

How can we know whether pupils have learned the meaning of a fact?

Note: This is the most critical problem in teaching, both by machine or "by hand"! Quite aside from the question of evaluation for grading, the real problem is to discover what meaning facts have for the student. The expected meaning, that is the meaning intended by the programmer, may not be apprehended completely or correctly by the student.

ANSWER

This problem must be attacked by the establishment of "feedback". Feedback means that the teacher must find ways of determining what meanings are getting through to the students. All of this means that the problem is one of communication, but there is more to it than that: We need a test, or means of measuring whether the pupil really has "learned the fact". Perhaps the best test is whether the pupil can arrive at the fact from several different starting points. Thus if the fact consists of the number 13, the pupil may respond with this number when stimulated by several different questions, such as: What is a prime number ending in 3; what is a "baker's dozen"; how many cards in a suit; what numbers are unlucky; etc.

CONCLUSIONS

All of the above problems have answers which are important both for teachers and machine programmers. Many other problems exist for both; but these have been presented because they represent areas in which teachers can improve. If we are to learn from this research, it will mean that:

1. We will avoid over-loading high ability pupils.
2. We will avoid under-loading average and low-ability pupils.
3. We will plan our teaching around the pupil response expected.
4. We will expect pupil responses which are appropriate to their age and previous experiences.
5. We will develop skills first, then use the skills in solving meaningful problems.
6. We will plan motivational activities which result in involving the pupil in meaningful activities appropriate to the learning task.
7. We will consider intelligence of pupils as only one factor in a complex of factors which influence the level and pace of learning.
8. We will be careful to "touch all the bases" in our teaching, without taking it for granted that what is obvious to us is obvious to the pupil.
9. We will strive to keep our instruction orderly, coherent, articulated, and meaningful.
10. We will constantly evaluate the classroom situation to see if we have good two-way communication between pupils and teacher.

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